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Forest Tables—Western Yellow Pine.

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FOREST TABLES FOR WESTERN YELLOW PINE.

INTRODUCTION.

Forest tables for western yellow pine include *Pinus ponderosa* proper, the variety *scopulorum*, and *Pinus jeffreyi*. In gathering the data no attempt was made to segregate the species, since the distinction is too slight to be reflected in form or growth tables. The data used in the construction of these tables were collected by field parties[a] in connection with various projects mainly on the National Forests; they were not gathered according to a set plan, but nevertheless are sufficient for the immediate requirements of exploitation and forest management. Cooperation is requested in the collection of more complete measurements for extending and revising the tables. In the National Forests, technical assistants, timber-sale inspectors, and lumbermen supervising cuttings can render valuable aid in this direction.

The widely varying factors of temperature and rainfall in different parts of the western yellow pine region bring about a corresponding variation in the development of the tree. This affects both the rate of growth and the form, and necessitates the recognition of three regions in which the tree differs widely. These regions are: the isolated Black Hills region; Arizona, New Mexico, southern Colorado, and the lower and drier mountains of southern California; northern California, Oregon, Washington, and the moister parts of Montana.

The first two regions are marked by a light rainfall; there the tree makes slow growth, has a short full stem, and forms open stands. The third region has a much heavier rainfall, which makes more rapid growth, a more slender stem, and rather dense stands. These characteristics are most conspicuous in the volume tables, but can also be traced in the stand, height, and diameter-growth tables. The boundaries of the regions are not always sharply drawn and intermediate stands may occasionally be found that will require nice judgment in the use of the tables.

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[a] The field parties for the different regions were under the direction of the following men:

Prescott National Forest, Ariz. (working plan), A. E. Cohoon (1901).
California and Oregon (sugar pine study), R. D. Swales (1901).
Black Hills, S. Dak. (western yellow pine study), Coert Dubois (1902).
Colfax Co., N. Mex. (study and planting plan), A. F. Hawes (1903).
Black Hills, S. Dak. (western yellow pine study), H. M. Curran (1904).
Archuleta County, Colo. (western yellow pine study), H. M. Curran (1904).
Butte and Madera counties, Cal. (western yellow pine study), A. W. Cooper (1904).
Flathead and Missoula counties, Mont. (western yellow pine study), S. J. Record (1904).
Stevens County, Wash. (working plan), A. K. Chittenden (1904).
San Francisco Mountains National Forest, Ariz. (timber sales), T. S. Woolsey, Jr. (1906).

STANDS.

Five tables of stands containing western yellow pine are given. They illustrate the different regions, and give associated species and relative development as seen in the diameters attained. The size of the tree increases from the Black Hills to Arizona, to Colorado, to Montana, to eastern Washington, and finally makes a decided increase to the west slope of the Sierras in California and Oregon. While yellow pine attains its maximum size in the central and northern Sierras of California and Oregon in mixture with sugar pine and white fir, on the lower and drier foothills it occurs in pure stands, or with a few scrubby oaks, and has a form very similar to that found in Arizona.

Table 1 shows the average stand per acre on township 1 south, range 3 east, of the Black Hills National Forest. It shows a large percentage of "insect-killed" timber, but does not indicate an average loss from that source. The column of totals gives the stand before the invasion of the beetle. It shows a denser stand than is found in many parts of the Black Hills, and gives the possibilities of the region. The stands here are mainly pure, and mostly very open; diameters above 30 inches are infrequent and the greater part of the stand is under 18 inches.

TABLE 1.—*Stand in township 1 south, range 3 east, Black Hills National Forest, South Dakota.*

[Altitude, 5,000–6,000 feet.]

TREES 5 INCHES AND OVER, BREASTHIGH DIAMETER, ON 351 ACRES.

Diameter breasthigh.	Average number of trees per acre.					
	Sound.	Insect killed.	Unsound.	Burnt.	Dead.	Total.
Inches.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
5	7.87	0.41	1.14	0.03	0.27	9.72
6	8.32	.79	1.30	.06	.20	10.67
7	7.07	1.20	1.26	.07	.16	9.76
8	5.87	1.46	1.15	.08	.13	8.69
9	4.78	1.70	1.06	.07	.12	7.73
10	4.25	1.91	1.07	.03	.09	7.35
11	3.53	1.78	.81	.03	.06	6.21
12	3.22	1.60	.93	.05	.06	5.86
13	2.65	1.44	.83	.03	.06	5.01
14	2.23	1.36	.70	.04	.02	4.35
15	1.81	1.12	.55	.03	.02	3.53
16	1.26	.80	.47	.02	.03	2.58
17	.88	.57	.36	.03	.02	1.86
18	.68	.45	.32	.02	.01	1.48
19	.46	.38	.24	.01	.01	1.10
20	.31	.28	.18	.01	....	.78
21	.19	.17	.17	....	.01	.54
22	.12	.12	.09	.01	.01	.35
23	.06	.06	.05	....	....	.17
24	.04	.05	.05	....	....	.14
25	.03	.02	.04	....	.01	.10
26	.01	.02	.03	....	....	.06
27	.01	.01	.01	....	....	.03
28	.01	.02	.02	....	....	.05
29	....	.01	....	....	....	.01
30	.01	.01	.01	....	....	.03
31	....	....	.01	....	....	.01
Total	55.67	17.74	12.85	.62	1.29	88.17
Per cent	63.14	20.12	14.58	.70	1.46	100.00

TREES 12 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	13.98	8.49	5.06	0.25	0.26	28.04
Per cent	49.86	30.28	18.04	.89	.93	100.00

TREES 18 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	1.93	1.60	1.22	0.05	0.05	4.85
Per cent	39.79	32.99	25.16	1.03	1.03	100.00

Table 2 gives a representative stand in the Prescott National Forest, Arizona. Western yellow pine is the principal timber tree. There are more trees 18 inches and over than in the Black Hills, and trees 30 to 40 inches are frequent. The forest here is usually more open than that in the Black Hills.

TABLE 2.—*Stand in the Prescott National Forest.*

[Altitude, 5,000–6,000 feet.]

TREES 5 INCHES AND OVER, BREASTHIGH DIAMETER, ON 128 ACRES.

Diameter, breasthigh.	Average number of trees per acre.				
	Western yellow pine.	Oaks.	Firs.	One-seed juniper.	Total.
Inches.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
5	5.47	3.65	0.04	0.02	....
6	2.24	2.88	.05	.02	....
7	2.00	2.82	.03	.02	....
8	1.92	2.44	.01	.05	....
9	1.40	1.84	.02	.02	....
10	1.42	1.50	.07	.02	....
11	1.30	1.16	.05	.02	....
12	1.48	1.03	.01	.02	....
13	1.07	.88	.02	....	....
14	1.23	.70	.02	.01	....
15	1.10	.62	.01	.04	....
16	.95	.59	.06	.02	....
17	.80	.39	.02	.02	....
18	.95	.41	.04	.02	....
19	.89	.23	.02	.02	....
20	.71	.17	.03	.02	....
21	.66	.07	.04	....	....
22	.48	.09	.02	.01	....
23	.44	.05	.01	.02	....
24	.36	.02	.02	.04	....
25	.23	.02	....	.01	....
26	.11	.02	.03	.01	....
27	.17	....	.03	.02	....
28	.12	.01	.02	.02	....
29	.05	....	.04	....	....
30	.06	.01	.01	.02	....
31	.01	....	.01	.01	....
32	.02	....	....	....	....
33	....	.01	.01	.01	....
34	.01	....	.01	....	....
35	.01	....	....	....	....
37	.01	....	.02	....	....
Total	27.67	21.61	.77	.51	50.56
Per cent	54.73	42.74	1.52	1.01	100.00

TREES 12 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	11.92	5.32	0.50	0.34	18.08
Per cent	65.93	29.42	2.77	1.88	100.00

TREES 18 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	5.29	1.11	0.36	0.23	6.99
Per cent	75.68	15.88	5.15	3.29	100.00

Table 3 shows a stand of timber in Flathead and Missoula counties, Mont. Western yellow pine is the principal timber tree at the lower altitudes, and in favorable situations it occurs with Douglas fir, western larch, and lodgepole pine. Western yellow pine occurs here in much denser stands than in the Black Hills or in Arizona and reaches a larger diameter; in density of stand and in relation of height to diameter it more nearly approaches the development attained in California. There are, however, frequent open stands in the lower and drier foothills where the tree form more nearly resembles that of Arizona.

TABLE 3.—*Stand in Flathead and Missoula counties, Mont.*

[Altitude, 3,000-4,000 feet.]

TREES 1 INCH AND OVER, BREASTHIGH DIAMETER, ON 13.6 ACRES.

Diameter, breast-high.	Average number of trees per acre.								
	Western yellow pine.			Douglas fir.		Western larch.		Lodge-pole pine.	Total.
	Sound.	Dead.	Cull.	Sound.	Dead.	Sound.	Dead.	Sound.	
Inches.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
1-4	30.96	5.81		34.85	0.07	12.28		10.66	
5	11.10	.51		3.97	.07	.80	0.07	1.03	
6	8.31	.74	0.07	3.16		.51	.07	.66	
7	6.62	.07	.07	1.84		.22		1.25	
8	5.59	.37		1.62		.37		.88	
9	3.90	.29		1.18		.22		.44	
10	3.90	.22	.07	1.69		.37		.81	
11	2.65	.22	.07	.51		.15	.07	.37	
12	3.01			.37		.44		.51	
13	3.38			.37	.07	.30		.29	
14	2.72	.15	.07	.88		.36	.07		
15	2.21			.59		.15			
16	2.43	.07	.07	.74	.07	.29		.07	
17	2.57	.74	.07	.37		.36	.07		
18	1.62	.07		.44		.30			
19	1.47	.29		.37		.14			
20	1.69	.22		.37		.15	.15		
21	1.32			.15		.15			
22	1.18	.07		.29		.15	.07		
23	.66	.07		.15		.51			
24	.88			.29	.07	.07			
25	.96	.15		.37		.07			
26	1.10			.07		.22			
27	.66		.07			.07			
28	.37			.07					
29	.51			.07		.14			
30-34	1.25	.22		.07		.21			
35-39	.44		.07			.07			
40-44	.07								
45-47	.07			.07					
Total	103.60	10.28	.63	54.92	.35	19.07	.57	16.97	206.39
Per cent	50.20	4.98	.30	26.61	.17	9.24	.28	8.22	100.00

TREES 5 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	72.64	4.47	0.63	20.07	0.28	6.79	0.57	6.31	111.76
Per cent	65.00	4.00	.56	17.96	.25	6.07	.51	5.65	100.00

TREES 12 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	30.57	2.05	0.35	6.10	0.21	4.15	0.36	0.87	44.66
Per cent	68.45	4.59	.78	13.66	.47	9.29	.81	1.95	100.00

TREES 18 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	14.25	1.09	0.14	2.78	0.07	2.25	0.22		20.80
Per cent	68.51	5.24	.67	13.37	.34	10.81	1.06		100.00

TREES 24 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	6.31	0.37	0.14	1.01	0.07	0.85			8.75
Per cent	72.12	4.22	1.60	11.54	.80	9.72			100.00

Table 4 shows a stand in eastern Washington that is very similar in composition to the forest in western Montana, though there are fewer trees per acre.

TABLE 4.—*Stand on the Van Dissel tract, Stevens County, Wash.*

[Altitude, 3,000-4,000 feet.]

TREES 2 INCHES AND OVER, BREASTHIGH DIAMETER, ON 20 ACRES.

Diameter, breasthigh.	Average number of trees per acre.					Total.
	Western yellow pine.	Douglas fir.	Lodgepole pine.	Western larch.	Sitka spruce.	
Inches.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
2-4	10.05	9.05	4.75	1.45	0.10	....
5	1.95	1.15	.35	.25	....	....
6	1.40	1.60	.65	.05	....	....
7	1.00	1.30	1.05	.40	....	....
8	1.15	1.50	.50	.20	....	....
9	1.40	1.35	.30	.15	....	....
10	.80	1.05	.20	.15	....	....
11	.65	.85	.25	.10	....	....
12	.55	.75	.15	.30	....	....
13	.45	.35	.15	.10	....	....
14	.75	.85	....	.05	....	....
15	.65	.15	....	.25	....	....
16	.50	.40	.05	.15	....	....
17	.70	.40	.05	.20	....	....
18	.65	.55	....	.10	....	....
19	.40	.35	....	.25	....	....
20	.25	.60	....	.10	....	....
21	.80	.20	....	.05	....	....
22	.45	.15	....	.05	....	....
23	.55	....	....	.15	....	....
24	.20	.10	....	.40	....	....
25	.50	.10	....	.10	....	....
26	.30	.15	....	....	....	....
27	.40	.10	....	.15	....	....
28	.40	.20	....	.10	....	....
29	.30	.15	....	.10	....	....
30-34	.80	.10	....	.30	....	....
35-39	.65	.10	....	....	....	....
40-41	....	.10	....	....	....	....
Total	28.65	23.70	8.45	5.65	0.10	66.55
Per cent	43.05	35.61	12.70	8.49	.15	100.00

TREES 5 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	18.60	14.65	3.70	4.20	....	41.15
Per cent	45.20	35.60	8.99	10.21	....	100.00

TREES 12 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	10.25	5.85	0.40	2.90	....	19.40
Per cent	52.84	30.15	2.06	14.95	....	100.00

TREES 18 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	6.65	2.95	....	1.85	....	11.45
Per cent	58.08	25.76	....	16.16	....	100.00

Table 5 shows a stand of timber on the west slope of the Cascades in Klamath County, Oreg. This shows yellow pine in mixture with sugar pine and white fir. Douglas fir forms a large part of the forest here, but disappears farther south as shown in Table 6. Large diameters, occasionally exceeding 60 inches, are found in all species.

The yield of this stand is estimated as follows:

	Per acre.
Western yellow pine	18,000
Sugar pine	12,000
Douglas fir	15,000

TABLE 5.—*Stand at Pokegama, Klamath County, Oreg.*

[Altitude, about 4,000 feet.]

TREES 5 INCHES AND OVER, BREASTHIGH DIAMETER, ON 84 ACRES.

Diameter breast-high.	Average number of trees per acre.					
	Douglas fir.	Western yellow pine.	Incense cedar.	Sugar pine.	White fir.	Total.
Inches.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
5	0.70	0.80	0.82	0.51	0.65	....
6	.95	.92	.87	.35	.54	....
7	.69	.73	.75	.23	.43	....
8	.97	.77	.86	.25	.50	....
9	.77	.52	.61	.25	.39	....
10	.84	.67	.58	.26	.30	....
11	.80	.55	.52	.12	.18	....
12	.75	.50	.58	.12	.24	....
13	.57	.42	.55	.15	.19	....
14	.61	.55	.62	.14	.13	....
15	.76	.37	.55	.21	.20	....
16	.57	.27	.50	.13	.11	....
17	.47	.37	.49	.12	.14	....
18	.70	.21	.51	.12	.14	....
19	.72	.40	.30	.17	.19	....
20	.68	.50	.38	.12	.13	....
21	.44	.33	.26	.11	.19	....
22	.49	.36	.38	.19	.15	....
23	.44	.32	.26	.19	.11	....
24	.77	.29	.32	.14	.07	....
25	.35	.44	.25	.14	.15	....
26	.47	.44	.32	.15	.09	....
27	.29	.32	.40	.12	.07	....
28	.42	.43	.15	.19	.08	....
29	.33	.40	.20	.08	.09	....
30–34	1.40	1.62	.81	.62	.24	....
35–39	.84	1.47	.62	.58	.14	....
40–44	.54	.91	.28	.60	.04	....
45–49	.27	.63	.09	.56	....	....
50–54	.23	.12	.11	.28	....	....
55–59	.03	.11	.01	.17	....	....
60–64	.05	.02	.01	.19	....	....
65–67	.01	.01	....	.03	....	....
Total	18.92	16.77	13.96	7.59	5.88	63.12
Per cent	29.97	26.57	22.12	12.02	9.32	100.00

TREES 12 INCHES AND OVER, BREASTHIGH DIAMETER.

	Douglas fir.	Western yellow pine.	Incense cedar.	Sugar pine.	White fir.	Total.
Total	13.20	11.81	8.95	5.62	2.89	42.47
Per cent	31.08	27.81	21.07	13.23	6.81	100.00

TREES 18 INCHES AND OVER, BREASTHIGH DIAMETER.

	Douglas fir.	Western yellow pine.	Incense cedar.	Sugar pine.	White fir.	Total.
Total	9.47	9.33	5.66	4.75	1.88	31.09
Per cent	30.46	30.01	18.20	15.28	6.05	100.00

TREES 24 INCHES AND OVER, BREASTHIGH DIAMETER.

	Douglas fir.	Western yellow pine.	Incense cedar.	Sugar pine.	White fir.	Total.
Total	6.00	7.21	3.57	3.85	0.97	21.60
Per cent	27.78	33.38	16.53	17.82	4.49	100.00

Table 6 shows a stand farther south on the west slope of the Sierras in Madera County, Cal. The same species, except Douglas fir, are represented here as in Table 5. The diameters run very high, especially of yellow and sugar pine.

Lower down in the foothills of the Sierras there is an open stand of yellow pine which resembles that in Arizona and Colorado.

TABLE 6.—*Stand at 5,000 feet elevation, Madera County, Cal.*

TREES 1 INCH AND OVER, BREASTHIGH DIAMETER, ON 20 ACRES.

Diameter, breasthigh.	Average number of trees per acre.					
	Incense cedar.	White fir.	Western yellow pine.	Sugar pine.	California black oak.	Total.
Inches.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
1–4	8.60	7.75	2.70	5.30	0.05	
5	2.00	1.10	.90	.85	.05	
6	1.10	.50	.55	.35		
7	1.45	.65	.85	.40		
8	1.45	.75	.45	.40		
9	1.20	.45	.40	.25		
10	1.10	.65	.50	.40	.20	
11	1.30	.50	.55	.60	.35	
12	.80	.55	.35	.40	.15	
13	.60	.30	.35	.15	.15	
14	1.10	.20	.55	.35	.20	
15	.80		.70	.05	.25	
16	.80	.35	1.00	.10	.05	
17	.80	.20	.45	.25	.15	
18	.40	.35	.20	.15	.10	
19	.55	.10	.20	.35	.05	
20	.55	.30	.35	.35	.15	
21	.45	.15	.55	.20	.05	
22	.60	.20	.35	.05	.05	
23	.70	.45	.35	.10	.05	
24	.80	.15	.55	.35	.05	
25	.60	.45	.15	.20	.05	
26	.45	.35	.35	.15		
27	.35	.30	.45	.20		
28	.40	.25	.35	.25		
29	.45	.30	.40	.15		
30–34	3.30	2.00	1.25	1.20	.05	
35–39	2.40	2.10	1.15	1.10	.10	
40–44	1.80	1.55	1.35	1.20		
45–49	1.15	1.10	1.35	1.05		
50–54	.30	.55	.75	1.60		
55–59	.10		.10	.35		
60–62				.25		
65–67			.10	.05		
71–84			.05	.10		
Total	38.45	24.60	20.65	19.25	2.30	105.25
Per cent	36.53	23.37	19.62	18.29	2.19	100.00

TREES 5 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	29.85	16.85	17.95	13.95	2.25	80.85
Per cent	36.92	20.84	22.20	17.26	2.78	100.00

TREES 12 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	20.25	12.25	13.75	10.70	1.65	58.60
Per cent	34.56	20.90	23.46	18.26	2.82	100.00

TREES 18 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	15.35	10.65	10.35	9.40	0.70	46.45
Per cent	33.04	22.93	22.28	20.24	1.51	100.00

TREES 24 INCHES AND OVER, BREASTHIGH DIAMETER.

Total	12.10	9.10	8.35	8.20	0.25	38.00
Per cent	31.84	23.95	21.97	21.58	.66	100.00

HEIGHT.

Under like climatic conditions the height of a tree is an index of site quality. In Table 7 varying factors, such as density and rainfall, affect the form of the tree, and though yellow pine in the Black Hills has a greater height than in Arizona it is due entirely to a denser stand, for the diameter growth is much less. Evidently this height table can not be used as a comparative index of site quality without constant reference to the diameter growth (Table 12, page 15) and the stand tables for the same regions.

The heights for Stevens County, Wash., were doubtless taken in a maximum stand and are greater than an average for the region. The average height for the region would more nearly approach that given for Montana.

TABLE 7.—*Height in several regions.*

Diameter, breasthigh.	Prescott National Forest, Arizona.		Archuleta County, Colo.		Black Hills National Forest, South Dakota.		Flathead and Missoula counties, Mont.		Butte and Madera counties, Cal.		Stevens County, Wash.	
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
Inches.	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*
1									9	23		
2							18	2	13	88		
3							24	5	17	78		
4							31	12	21	82		
5	21	29	19	31	29	29	37	15	26	88		
6	24	75	22	30	34	46	44	13	30	83		
7	27	97	27	30	40	60	49	10	35	99		
8	30	107	31	27	45	54	54	21	40	62		
9	33	120	37	16	50	58	58	13	45	63		
10	37	119	43	18	54	44	62	16	50	69		
11	40	127	48	10	58	47	66	18	55	41		
12	43	138	53	2	62	66	70	22	60	44		
13	46	117	57	9	65	118	73	34	65	40		
14	48	116	61	16	68	217	76	35	70	47		
15	51	136	65	20	71	225	79	51	74	38		
16	54	115	68	38	73	236	81	61	79	43		
17	57	140	71	32	75	153	84	53	84	29	106	4
18	59	137	74	40	77	152	86	63	88	33	108	7
19	62	106	77	43	79	92	89	43	92	27	109	7
20	65	134	79	54	80	69	91	61	97	27	110	14
21	67	91	82	50	82	69	93	42	101	27	110	28
22	70	88	84	49	83	20	95	29	105	38	111	12
23	72	91	86	51	84	37	98	26	109	38	113	13
24	74	64	88	49	86	15	100	32	112	68	115	12
25	76	63	90	47	87	11	102	29	116	67	118	19
26	78	40	92	38	88	1	104	18	119	55	122	18
27	80		94	35	89	5	105	17	122	67	126	10
28	82	32	96	23	90	4	107	21	125	58	130	12
29	83	18	97	28	91		109	12	128	53	134	6
30	85	26	99	18	93		111	15	131	63	137	8
31	86	4	100	14			113	17	133	38	140	6
32	87	4	102	13			114	9	136	34	142	4
33	88	6	103	9			116	7	138	30	143	5
34	89	3	104	9			118	5	140	29	145	1
35	90		106	3			120	4	142	35	146	1
36	91						121	3	144	28	146	1
37							123		146	26	147	2
38							124	2	148	20		
39							126	1	150	20		
40							127	1	152	14		
41									153	17		
42									155	25		
43									157	20		
44									158	21		
45									159	17		
46									161	7		
47									162	7		
48									163	11		
49									164	9		
50									166	7		
51									167	7		
52									168	3		
53									169	3		
54									170	1		
Total		2,343		852		1,828		838		2,067		190

Table 8 gives heights for Flathead and Missoula counties, Mont., classified in types. The basis for the smaller diameters is not sufficient to warrant the drawing of definite conclusions. The mixed slope type has poorest height growth. Douglas fir enters the mixture strongly on the west and south slopes, and that indicates a rather dry soil. Quality classes would seem to be a better method of classification. In this case the pure slope and mixed flat types might be thrown together as Quality I, pure flat as Quality II, and mixed slope as Quality III.

TABLE 8.—*Height for various types in Flathead and Missoula counties, Mont.*

Diameter, breast-high.	Mixed slope.		Pure flat.		Pure slope.		Mixed flat.	
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
Inches.	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*
2							17	2
4			24	1			31	16
6	32	1	33	3	44	1	44	23
8	41	8	43	4	54	7	56	19
10	50	2	53	5	63	11	66	13
12	57	8	63	6	70	8	74	18
14	64	16	72	13	77	14	81	26
16	70	21	80	32	83	35	87	24
18	75	20	87	30	88	41	92	25
20	80	19	93	26	92	31	97	28
22	85	8	98	14	95	25	101	24
24	89	13	102	9	99	17	105	19
26	93	7	106	8	102	12	108	20
28	97	6	110	5	104	13	112	14
30	101	2	113	3	107	10	115	13
32	105	3			109	4	118	17
34					110	5	120	6
36							122	7
38							124	2
40							128	1
Total		134		159		234		317

CLEAR LENGTH.

Table 9 contains average "clear lengths" for yellow pine in Flathead and Missoula counties, Mont., Prescott National Forest, and the Black Hills National Forest. The first two are very similar. The Black Hills pine has a considerably larger clear length, due partly to its greater age, partly to other influences.

The interpretation of "clear length" by different field men will always cause confusion when results are to be compared; to some it will mean the length of trunk absolutely free from branches, to others it will mean the length free from living branches; to others still, the length to the first branch 2 inches in diameter, living or dead. The interpretation should be, that part of the tree which will furnish almost entirely clear lumber. This would allow an occasional small knot that might be eliminated without appreciable waste in cutting into logs or in sawing at the mill. The judgment of the measurer must always be exercised to some extent.

TABLE 9.—*Clear length by regions.*

Diameter, breast-high.	Flathead and Missoula counties, Mont.		Prescott National Forest, Arizona.		Black Hills National Forest, South Dakota.	
	Clear length.	Basis.	Clear length.	Basis.	Clear length.	Basis.
Inches.	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Fcet.*	*Trees.*
3	5	1				
4	6	2				
5	7		7	25	14	29
6	8	2	8	68	17	48
7	9	2	9	92	19	65
8	11	10	10	105	22	54
9	12	3	11	118	24	59
10	13	11	12	118	26	38
11	14	8	14	124	28	34
12	15	12	15	138	29	48
13	16	26	16	117	31	99
14	17	21	17	116	31	190
15	18	28	18	136	32	206
16	19	35	18	115	32	216
17	19	35	19	140	33	140
18	20	42	20	137	33	148
19	21	29	21	106	33	88
20	22	50	22	134	34	69
21	23	20	23	91	34	69
22	24	27	23	88	34	21
23	24	25	24	89	34	32
24	25	28	25		35	16
25	26	27	25	63	35	12
26	26	17	26	40	35	2
27	27	18	27	24	36	3
28	27	18	28	32	36	4
29	28	17	28		37	
30	28	14	29	26	37	
31	28	17	29			
32	28	9	30	4		
33	28	7	30	6		
34	28	5	30			
35	29	5	31			
36	29	3	31	1		
37	29					
38	29	2				
39	29					
40	29	1				
Total		577		2,253		1,690

GROWTH.

HEIGHT GROWTH OF SEEDLINGS.

Table 10 shows averages of seedling height growth. This growth is affected to such an extent by local conditions that tables not based on a very large number of measurements, taken from all qualities of locality, can not be closely compared. The parallel columns will furnish a rough comparison and give some idea of development. All of the measurements indicate that the growth for the first six years is very slow.

TABLE 10.—*Seedling height growth by types and regions.*

Age.	"Dry slope," Bartlett tract, Colfax County, N. Mex.		"Pure slope," Flathead and Missoula counties, Mont.		Black Hills National Forest, South Dakota.		Big Bug Mesa, 6,500 feet elevation, Prescott National Forest, Arizona.		"Full light," Crane Valley, Madera County, Cal.	
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
Years.	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*	*Feet.*	*Trees.*
1			0.1	3					0.1	4
2	0.5	3	.2	3					.3	10
3	.7	10	.3	5					.6	12
4	.9	15	.5	11	1.2		1.2	1	1.1	37
5	1.1	24	.7	11	1.5		1.6	1	1.7	43
6	1.4	29	1.0	11	1.8	3	2.0	4	2.3	19
7	1.7	35	1.3	11	2.2	5	2.6	6	2.9	16
8	1.9	45	1.8	11	2.5	7	3.1	5	3.5	22
9	2.2	30	2.4	11	2.9	16	3.7	7	4.2	24
10	2.4	47	2.9	9	3.3	15	4.3	10	4.8	32
11	2.7	37	3.3	7	3.7	10	4.9	12	5.5	8
12	3.0	53			4.2	10	5.6	11	6.1	3
13	3.4	43			4.8	10	6.4	19	6.8	3
14	3.8	42			5.5	3	7.3	28		
15	4.2	42			6.2	13	8.1	17		
16	4.6	39			7.0	6				
Total		494		93		98		121		233

Table 11 gives averages of height growth by types for seedlings in Flathead and Missoula counties, Mont. Seedling growth is very slow in mixed stands, because of the dryness of the mixed slopes and the density of the mixed flats. On pure slopes and pure flats seedling height growth is almost identical.

TABLE 11.—*Seedling height growth for various situations in Flathead and Missoula counties, Mont.*

Age.	Mixed slope.		Mixed flat.		Pure slope.		Pure flat.	
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
Years.	*Feet.*	*Internode counts.*	*Feet.*	*Internode counts.*	*Feet.*	*Internode counts.*	*Feet.*	*Internode counts.*
1	0.1	86	0.1	62	0.1	3	0.1	18
2	.2	83	.3	62	.2	3	.2	26
3	.4	86	.5	67	.3	5	.4	45
4	.5	90	.6	72	.5	11	.6	56
5	.7	97	.8	79	.7	11	.8	64
6	.9	105	1.0	81	1.0	11	1.1	67
7	1.1	103	1.3	82	1.3	11	1.4	60
8	1.3	100	1.5	80	1.8	11	1.8	60
9	1.5	96	1.8	74	2.4	11	2.3	40
10	1.7	89	2.1	63	2.9	9	2.9	38
11	1.9	61	2.4	44	3.3	7	3.7	17
12	2.1	44	2.7	24			4.5	16
13	2.2	30	2.9	10			5.5	7
14	2.4	24	3.1	5				1
15	2.5	18	3.2	1				1
Total		1,112		806		93		516

DIAMETER GROWTH.

Table 12 contains averages of diameter growth from different regions. The Black Hills region shows the slowest growth, due mainly to lack of rainfall and a shorter growing season. Montana has the next slowest growth, with possibly a slightly larger rainfall than the Black Hills. Colorado and Arizona follow in order with approximately the same rainfall, but with longer growing seasons and more open forest, which increase diameter growth. The growth in Stevens

County, Wash., is excellent for the latitude and rainfall. The west slope of the Rocky Mountains must have a favorable effect on the moisture conditions there. The west slopes of the Sierras in central and northern California show a magnificent growth, which is auspicious for forest management. The rainfall there is heaviest in the entire range of yellow pine. Soil and other conditions no doubt have their influence on growth, but the extent is not yet ascertainable. In all measurements, and especially in diameter growth, it must be borne in mind that individual trees often greatly exceed the average. In the Black Hills it takes one hundred and twenty years for the average tree to reach the merchantable size of 10.5 inches, yet some individual trees reach that diameter in a much shorter time.

TABLE 12.—*Diameter growth by general regions.*

Age.	Nemo, Black Hills National Forest, South Dakota.		Flathead and Missoula counties, Mont.		Pagosa Junction, Archuleta County, Colo.	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
Years.	*Inches.*		*Inches.*		*Inches.*	
10	....	Decade measurements on 886 1.5-foot stumps 98-370 years old.	....	Decade measurements on 271 3-foot stumps 91-483 years old.	....	Decade measurements on 130 2-foot stumps 72-332 years old.
20	1.0		0.8		1.2	
30	1.9		2.2		2.9	
40	3.1		3.7		4.9	
50	4.2		5.1		6.8	
60	5.3		6.5		8.6	
70	6.2		7.9		10.2	
80	7.2		9.0		11.7	
90	8.1		10.1		12.8	
100	8.9		11.2		13.8	
110	9.7		12.2		14.7	
120	10.5		13.1		15.5	
130	11.2		14.0		16.2	
140	11.7		14.7		16.9	
150	12.2		15.2		17.5	
160	12.7		15.8		17.9	
170	13.1		16.3		18.4	
180	13.4		16.7		18.8	
190	13.8		17.0		19.3	
200	14.2		17.5		19.6	

Age.	Prescott National Forest, Arizona.		Stevens County, Wash.		Butte and Madera counties, Cal.	
	Diameter breast high.	Basis.	Diameter breast high.	Basis.	Diameter breast high.	Basis.
Years.	*Inches.*		*Inches.*		*Inches.*	
10	....	Decade measurements on 189 2-foot stumps 31-308 years old.	....	Decade measurements on 210 3-foot stumps 85-300 years old.	0.8	Decade measurements on 422 2.5-foot stumps 21-248 years old.
20	2.2		2.2		4.1	
30	4.3		4.5		7.1	
40	6.3		6.3		9.7	
50	8.1		7.9		12.2	
60	9.5		9.4		14.3	
70	10.8		10.8		16.2	
80	12.0		12.2		17.8	
90	13.0		13.5		19.4	
100	14.1		14.9		20.9	
110	15.2		16.2		22.2	
120	16.2		17.6		23.4	
130	17.1		18.9		24.5	
140	18.0		20.1		25.5	
150	18.7		21.2		26.5	
160	19.4		22.2		27.3	
170	20.0		23.2		28.0	
180	20.5		24.0		28.7	
190	21.0		24.7		29.2	
200	21.6		25.3		29.7	

Table 13 gives the variation in diameter growth for different types of forest in Flathead and Missoula counties, Mont. As would be inferred from the growth of seedlings (Table 11, p. 14) and relation of height to diameter (Table 8, p. 12), the mixed slope type shows the poorest diameter growth. The mixed flat with its denser stand has a retarded diameter growth, but produces the tallest trees (Table 8). The pure stands on flat and slope have the best diameter growth, and the slope type leads in height up to 18 inches (Table 8), but the flat type leads in diameter growth.

Table 13.—*Diameter growth in various types, Flathead and Missoula counties, Mont.*

Age.	Mixed slope.		Mixed flat.		Pure slope.		Pure flat.	
	Diameter breast high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
Years.	*In.*		*In.*		*In.*		*In.*	
20	....	Decade measurements on 47 3-foot stumps 107–475 years old.	0.7	Decade measurements on 51 3-foot stumps 143–470 years old.	0.9	Decade measurements on 121 3-foot stumps 81–400 years old.	0.9	Decade measurements on 92 3-foot stumps 103–269 years old.
30	0.8		2.1		2.0		2.3	
40	1.7		3.2		3.4		3.9	
50	2.7		4.3		5.0		5.5	
60	3.9		5.4		6.4		7.0	
70	5.0		6.3		7.8		8.5	
80	6.1		7.4		9.0		10.0	
90	7.2		8.5		10.3		11.4	
100	8.3		9.6		11.4		12.5	
110	9.2		10.6		12.4		13.3	
120	10.0		11.8		13.4		14.1	
130	10.7		12.8		14.1		14.9	
140	11.5		13.9		14.8		15.5	
150	12.1		14.7		15.5		16.1	
160	12.8		15.6		16.0		16.6	
170	13.4		16.3		16.5		17.1	
180	14.1		17.1		16.9		17.5	
190	14.6		17.7		17.1		17.9	
200	15.2		18.3		17.5		18.2	

VOLUME.

VARIATION ACCORDING TO REGION.

With the great variation in form of western yellow pine as shown by the relation of height to diameter (Table 7, p 11), in diameter growth (Table 12, p. 15), and in density of stand. as shown in the stand tables (pp. 5 to 10), it is not surprising that there is a large variation in volume. In considering volume this variation requires that three general regions be distinguished: the Black Hills; Arizona, Colorado, and open stands in the Rocky Mountain region and southern California where there is a deficiency of moisture; and the west slope of the Sierras in central and northern California and in Oregon, and possibly the best stands in eastern Washington and western Montana.

VOLUME IN BOARD FEET (SCRIBNER LOG RULE).

Each of the three general regions is represented by a volume table in board feet, to which is attached the top diameter cutting limit. The Black Hills region gives the largest volumes, with Arizona next, and California the smallest. Further, the utilization in the tops is closest in the Black Hills, Arizona next, and California least close. This is, to some extent, due to the form of the tree and to the difference of value of the poorer top logs in the different regions. However, this difference in utilization can account for only a part of the variation in volume, as shown by a comparison of the tables giving the volume of entire stem for California and the Black Hills.

Tables 14, 15, and 16 give, respectively, the board-foot contents for the three general regions. The Black Hills and the Arizona tables show volumes approaching each other rather closely, which is accounted for by the similarity in conditions in those regions. California, however, shows much smaller volumes. The smaller volume for California is best explained by the form tables on pages 22 and 23.

The tables were made up by scaling logs as cut by lumbermen. The logs varied in length from 10 to 18 feet. The larger part of the California trees were cut into 10-foot logs, and for that reason every advantage of taper gained by scaling short logs must be credited to the California table. The Black Hills table shows diameters down to 8 inches, since the smaller trees are merchantable there.

Trees much larger than 48 inches are found in California, but there were not sufficient data available for an extension of the table beyond that diameter. However, a fairly accurate estimate can be made by finding the volume of half the diameter, under the required height class, and multiplying by 4, since with equal heights the volumes vary as the squares of the diameters. As an illustration, in Table 16 a 24-inch, 150-foot tree contains 1,040 board feet; by the suggested method, a 48-inch tree, 150 feet high, should have 4 × 1,040, or 4,160 board feet. In the table it is given as 4,250. According to the table a 33-inch tree, 170 feet high, contains 2,330 board feet; a 66-inch tree of the same height should contain about 9,320 board feet. The volumes given for the larger diameters are conservative.

The relation between the Scribner scale and actual saw cut can not be given at this time. It varies with different saws, different log diameters, with the efficiency of the sawyers, and, most of all, with the kind of log. Rapidly tapering logs will give a larger overrun than cylindrical logs.

TABLE 14.—*Volume in board feet—Scribner rule—Black Hills National Forest, South Dakota.*

Diameter breasthigh.	Height of tree, feet—							Diameter of top inside bark.	Basis.
	40.	50.	60.	70.	80.	90.	100.		
Inches.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Inches.*	*Trees.*
8	20	25						6.0	6
9	25	35	45					6.3	4
10	35	45	55	65				6.5	17
11	45	55	70	85	100			6.8	22
12	55	70	90	110	130			7.0	47
13		85	105	130	155			7.3	100
14		105	125	150	185			7.6	200
15		125	150	175	210	245		7.9	214
16		145	175	205	245	285		8.4	225
17		170	200	240	280	325		8.9	146
18		195	230	270	320	375		9.4	146
19			265	310	365	425		10.1	87
20			300	350	405	475		10.8	63
21			340	395	460	530		11.5	50
22			380	440	510	585	650	12.1	32
23				490	565	645	720	12.8	36
24					620	710	800	13.4	13
25						785	880	13.9	11
Total									1,419

TABLE 15.—*Volume in board feet—Scribner rule—San Francisco Mountains National Forest, Arizona.*

Diameter breast-high.	Height of tree, feet—									Diameter of top inside bark.	Basis.
	40.	50.	60.	70.	80.	90.	100.	110.	120.		
Inches.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Inches.*	*Trees.*
12	50	60	70	80						8.3	
13	60	80	90	100						8.5	23
14	70	90	110	120	140	150				8.7	48
15	90	110	130	150	170	180	190			8.9	91
16	110	130	160	180	200	220	230	240		9.2	117
17	130	160	180	210	230	260	280	290	310	9.4	142
18	160	180	210	240	270	300	320	350	370	9.6	136
19	180	210	250	280	310	350	380	410	430	9.9	135
20	210	250	280	320	360	400	440	470	500	10.1	104
21	240	280	320	370	410	460	500	540	580	10.4	127
22	280	310	360	410	470	520	570	620	670	10.6	135
23		350	410	470	520	590	640	700	760	10.9	103
24		390	450	520	590	660	720	780	850	11.1	105
25		430	500	580	650	730	800	880	950	11.3	85
26		470	550	630	720	800	890	980	1,070	11.6	93
27			610	690	790	880	980	1,080	1,190	11.9	83
28			660	760	860	960	1,080	1,190	1,310	12.1	63
29				820	930	1,040	1,170	1,300	1,440	12.4	51
30				880	1,000	1,130	1,270	1,420	1,570	12.7	42
31				940	1,070	1,220	1,380	1,550	1,720	12.9	21
32				1,010	1,150	1,310	1,490	1,680	1,870	13.2	28
33					1,230	1,410	1,610	1,820	2,020	13.5	22
34					1,310	1,510	1,740	1,960	2,180	13.9	22
35					1,390	1,620	1,870	2,110	2,330	14.3	17
36					1,470	1,720	1,990	2,260	2,500	14.7	13
37						1,810	2,120	2,410	2,660	15.2	6
38						1,900	2,250	2,550	2,820	15.8	4
39							2,390	2,690	2,980	16.4	5
40							2,530	2,840	3,150	17.0	1
Total											1,822

Table 16.—*Volume in board feet—Scribner rule—California and Montana.*

Diameter breast-high.	Height of tree, feet—															Diameter of top inside bark.	Basis.
	50.	60.	70.	80.	90.	100.	110.	120.	130.	140.	150.	160.	170.	180.	190.		
Inches.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*In.*	*Trees.*
12	15	20	30	45												9.8	3
13	20	35	45	60	70											10.0	40
14	30	50	60	80	90											10.2	58
15	40	65	80	100	120											10.4	67
16	60	80	105	125	150	180	205									10.6	81
17	80	100	130	155	180	215	255									10.9	74
18	100	125	160	190	220	260	305	350								11.1	81
19		155	190	225	260	310	360	415								11.4	58
20		185	225	270	310	360	420	480	535	585						11.7	75
21		215	265	315	360	420	480	545	610	675						12.0	64
22		250	305	360	415	480	550	620	700	765	840					12.4	68
23		290	350	410	475	545	620	700	780	860	940	1,030				12.7	61
24			390	460	530	610	690	780	870	960	1,040	1,140	1,230			13.0	69
25			430	510	590	680	770	870	960	1,060	1,150	1,250	1,340			13.4	68
26			480	560	660	750	850	950	1,060	1,160	1,260	1,360	1,460			13.7	54
27					720	820	930	1,040	1,150	1,260	1,370	1,480	1,580			14.1	60
28					790	890	1,010	1,120	1,240	1,350	1,480	1,600	1,710			14.4	61
29					860	970	1,090	1,210	1,340	1,450	1,590	1,720	1,830			14.8	52
30					930	1,040	1,170	1,290	1,430	1,550	1,700	1,830	1,950			15.2	57
31					990	1,110	1,250	1,380	1,530	1,650	1,810	1,950	2,070			15.5	26
32					1,060	1,190	1,330	1,470	1,630	1,760	1,920	2,060	2,200			15.9	18
33					1,130	1,260	1,400	1,550	1,720	1,870	2,040	2,190	2,330	2,450	2,590	16.3	15
34					1,190	1,330	1,480	1,640	1,820	1,970	2,150	2,320	2,450	2,590	2,730	16.6	17
35						1,410	1,560	1,730	1,910	2,080	2,270	2,440	2,580	2,730	2,880	17.0	14
36						1,480	1,640	1,820	2,010	2,200	2,390	2,580	2,720	2,870	3,020	17.4	6
37						1,550	1,720	1,910	2,110	2,310	2,520	2,720	2,860	3,020	3,170	17.8	10
38						1,630	1,810	2,000	2,210	2,440	2,650	2,860	3,010	3,180	3,340	18.2	2
39						1,700	1,890	2,090	2,310	2,570	2,800	3,020	3,170	3,340	3,500	18.6	6
40						1,770	1,980	2,190	2,420	2,720	2,960	3,180	3,340	3,520	3,670	19.0	7
41									2,530	2,870	3,120	3,340	3,520	3,690	3,840	19.4	3
42									2,650	3,040	3,290	3,510	3,690	3,860	4,000	19.8	8
43										3,210	3,460	3,670	3,860	4,010	4,140	20.2	6
44										3,380	3,630	3,830	4,010	4,160	4,280	20.7	7
45										3,560	3,790	3,980	4,150	4,290	4,420	21.1	7
46										3,720	3,950	4,120	4,280	4,420	4,540	21.5	6
47										3,900	4,100	4,250	4,400	4,540	4,660	21.9	2
48										4,070	4,250	4,380	4,520	4,660	4,780	22.3	2
Total																	1,313

VOLUME OF ENTIRE STEM IN CUBIC FEET.

The measurements for volume of entire stem are complete enough for accurate stem volumes for the Black Hills and for California. The Arizona data contained measurements on the merchantable part of the tree only; hence there is no table of stem volume for Arizona. The Black Hills table will apply, with possibly a small deduction.

The volumes for the Black Hills (Table 17) were made up from measurements at 4-foot points for the smaller diameters and 10-foot points for the larger. The California analyses had 10-foot tapers. Table 18 was constructed entirely from the best part of the California data and its basis is considerably less than the corresponding board-foot table. The tops of the trees were figured as cones. In the California data the taper was not carried as far into the top (except for the 13, 14, and 15 inch trees) as that of the Black Hills; hence the part figured as a cone was longer and a larger error was introduced in the volume. However, this would not materially reduce the differences between the two tables. For the 13, 14, and 15 inch diameters the tapers were carried to equal points, and though the California trees are much younger the differences between the volumes in the two regions is very marked.

TABLE 17.—*Volume of the entire stem, Black Hills, South Dakota.*

Diameter breast-high.	Height of tree, feet—							Basis.
	30.	40.	50.	60.	70.	80.	90.	
Inches.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Trees.*
8	5.7	7.4	8.9	10.2				43
9	6.6	9.2	11.5	13.5				48
10	7.8	11.3	14.3	17.1	20.0			28
11	9.3	13.6	17.4	21.2	24.9			24
12		16.4	21.1	25.6	29.9	35.3		30
13			25.0	30.5	35.0	41.0		56
14			30.0	35.5	41.0	47.0		140
15			35.0	40.5	46.5	53.0	59.5	157
16			40.0	46.0	52.5	59.5	67.0	167
17			45.0	51.5	59.0	66.5	74.5	91
18				57.5	65.5	74.0	83.0	83
19				63.0	73.0	82.5	92.0	52
20				69.0	80.5	91.5	103.0	38
21					88.5	101.0	115.0	23
22					96.5	112.0	127.5	11
23						123.0	138.5	9
24						134.5	149.5	3
25						145.0	160.0	1
Total								1,004

NOTE.—The small number of trees and the long sections cut cause the form factor to vary irregularly, though within rather narrow limits (0.48 to 0.57), but the average, 0.53, when applied to a stand of varying diameters, will be within a maximum error of 5 per cent.

TABLE 18.—*Volume of the entire stem, Butte and Madera counties, California.*

Diameter breast-high.	Height of tree, feet—												Basis.
	50.	60.	70.	80.	90.	100.	110.	120.	130.	140.	150.	160.	
Inches.	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Cu.ft.*	*Trees.*
12	16	19	23	26	30								
13	19	23	27	31	35								40
14	22	27	31	36	40								47
15	25	30	35	41	46								38
16		34	40	46	52								42
17		38	45	52	59								24
18		42	50	58	67	77	88						33
19			55	65	75	86	97						27
20			61	72	84	95	107	118					27
21				79	92	104	117	129	143				26
22				87	101	113	127	141	155				36
23				95	109	123	138	153	168				37
24				103	117	133	149	166	182	197			46
25					126	144	162	179	195	213			39
26					135	155	174	193	210	229			36
27						167	188	207	226	246			40
28						180	201	223	242	264			38
29						194	216	238	260	282			32
30						208	230	254	278	302	330	358	42
31							246	270	295	321	347	376	8
32							261	285	311	339	366	395	5
33								299	326	355	384	414	7
34								313	342	372	401	434	5
35								327	357	388	420	456	7
36								341	371	404	439	477	4
37									386	420	459	502	4
38									400	437	479	528	1
39									414	455	502	560	2
40									428	474	526	592	2
41										495	552	622	1
42										517	580	649	3
43										541	610	675	1
44										566	638	700	4
45										590	666	726	3
46										616	693	751	1
47										644	720	776	
48										671	746	802	2
Total													710

NOTE.—The form factor varies from 0.38 to 0.45. The average, 0.42, will give very good results when applied to a stand composed of a number of diameter classes in the yellow pine-sugar pine belt.

VOLUME OF BARK.

Western yellow pine is generally thick-barked, though the thickness varies with individual trees. Accurate computations on 189 trees in the Black Hills and 94 trees in California show very consistent results in the volume of bark. As in all trees, the percentage of bark in relation to the total stem volume decreases as the volume of the tree increases, or, in other words, the increase in the bark volume does not keep pace with the increase in stem volume. This difference in ratio is less marked in thin-barked species.[a]

In relation to diameter, the percentage of bark for the Black Hills is much less than for California, partly due to the larger volume of the Black Hills trees. However, in the cubic feet of bark for the same diameter and height in both regions the difference is less marked.

TABLE 19.—*Amount of bark of western yellow pine in per cent of total stem volume.*

Diameter breast-high.	Volume of bark.	
	Black Hills.	California.
Inches.	*Per cent.*	*Per cent.*
8	17	....
10	16	....
12	16	24
14	15	22
16	14	21
18	13	20
20	13	19
22	12	18
24	12	17
26	....	16
28	....	15
30	....	14
34	....	13
40-44	....	13

The portion necessarily deducted from Tables 17 and 18 for unmerchantable material in top and stump will vary with the height of stump and with the diameter to which the top is utilized as well as with the size of the tree. The proportion of material that is lost is larger in small than in mature trees. For cordwood calculations the limb wood more than offsets the loss in top and stump. For saw-timber calculations cubic measure is seldom used. The unmerchantable part, allowing from 1-foot to 18-inch stumps and 8 to 10 inch tops, would vary from about 25 per cent in 12-inch trees to 15 per cent in 18-inch trees and 10 per cent in 24-inch trees for the Black Hills. For California it would be a little higher because of the longer tops. The amount to be deducted should be determined on the ground where the stump height and the closeness of utilization are known.

In case a deduction for both bark and "top and stump" is desired the top and stump should first be deducted and from the remainder a second deduction made for the bark, because the inclusion of the two percentages in one deduction would be making a double deduction for the bark on the top and stump. This point becomes important, however, only in the smaller trees where the percentages of waste are high. For instance, for a 12-inch tree a bark deduction of 24 per cent and a top and stump deduction of 25 per cent added by the wrong method would give a total deduction of 49 per cent, whereas by first deducting 25 per cent for top and stump and then deducting 24 per cent of the remaining 75 per cent for bark, the bark deduction would be 18 per cent of the total volume and the total deduction only 43 per cent.

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[a] See Circular 126, Forest Tables, Lodgepole Pine.

FORM.

Tables 20 and 21 give taper figures for the Black Hills; Table 22 gives these for California. Table 21 shows diameters outside the bark. A comparison of Tables 20 and 22 shows why the volumes in the two regions are so radically different. All heights are combined and the figures represent the characteristic developments of the two regions.

TABLE 20.—*Taper, Black Hills National Forest, South Dakota.*

[Diameter inside bark.]

Diameter breasthigh.	Height, feet—								Total height.	Basis.
	1.	10.	20.	30.	40.	50.	60.	70.		
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Trees.*
8	8.3	6.4	4.8						45	45
9	9.4	7.3	5.9	4.5					50	47
10	10.4	8.2	6.9	5.5	3.9				54	24
11	11.5	9.1	8.0	6.7	5.1				58	20
12	12.5	10.0	9.0	7.8	6.3	4.2			62	12
13	13.4	10.9	10.0	8.9	7.4	5.4			65	27
14	14.3	11.8	10.9	9.9	8.4	6.4			68	41
15	15.2	12.7	11.8	10.9	9.4	7.2	4.4		71	40
16	16.1	13.6	12.7	11.8	10.3	8.1	5.3		73	34
17	17.1	14.5	13.6	12.7	11.2	9.0	6.2		75	32
18	18.2	15.5	14.5	13.5	12.0	9.9	7.1		77	33
19	19.3	16.3	15.4	14.4	13.0	10.8	8.0		79	47
20	20.4	17.3	16.2	15.3	13.9	11.9	9.1		80	38
21	21.5	18.3	17.2	16.2	14.9	13.0	10.3	6.6	82	24
22	22.5	19.2	18.1	17.1	15.8	14.0	11.3	7.7	83	12
23	23.6	20.2	19.1	18.0	16.8	15.1	12.5	8.8	84	10
24	24.5	21.1	20.0	18.9	17.7	16.2	13.7	9.8	86	2
25	25.6	22.1	21.0	19.9	18.7	17.2	14.7	10.9	87	3
Total										491

Table 21.—*Taper, Black Hills National Forest, South Dakota.*

[Diameter outside bark.]

Diameter breasthigh.	Height, feet—								Total height.	Basis.
	1.	10.	20.	30.	40.	50.	60.	70.		
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Trees.*
8	9. 5	6. 9	5. 3	....	....	....	....	....	45	45
9	10. 7	7. 9	6. 4	5. 0	....	....		....	50	47
10	11. 9	8. 8	7. 4	6. 0	4. 3	....	....	....	54	24
11	13. 2	9. 8	8. 6	7. 2	5. 5	....	....	....	58	20
12	14. 3	10. 8	9. 7	8. 4	6. 8	4. 7	....	....	62	12
13	15. 3	11. 7	10. 8	9. 6	8. 0	6. 0	....	....	65	27
14	16. 3	12. 7	11. 7	10. 6	9. 1	7. 0	....	....	68	41
15	17. 3	13. 6	12. 7	11. 7	10. 1	7. 9	5. 0	....	71	40
16	18. 2	14. 5	13. 6	12. 6	11. 1	8. 8	5. 9	....	73	34
17	19. 3	15. 4	14. 5	13. 5	12. 0	9. 7	6. 8	....	75	32
18	20. 4	16. 5	15. 4	14. 4	12. 8	10. 6	7. 7	....	77	33
19	21. 5	17. 3	16. 4	15. 3	13. 8	11. 6	8. 7	....	79	47
20	22. 6	18. 3	17. 2	16. 2	14. 8	12. 7	9. 8	....	80	38
21	23. 7	19. 3	18. 2	17. 1	15. 8	13. 8	11. 0	7. 1	82	24
22	24. 7	20. 2	19. 1	18. 0	16. 7	14. 8	12. 0	8. 3	83	12
23	25. 8	21. 3	20. 1	19. 0	17. 7	16. 0	13. 3	9. 5	84	10
24	26. 7	22. 3	21. 1	19. 9	18. 7	17. 1	14. 5	10. 6	86	2
25	27. 8	23. 3	22. 1	21. 0	19. 7	18. 2	15. 6	11. 8	87	3
Total	....	....	....	....	....	....	....	....	....	491

Table 22.—*Taper, Butte County, Cal.*

[Diameter inside bark.]

Diameter breast-high.	Height, feet—									Average height.	Basis.
	1.	4.5.	10.	20.	30.	40.	50.	60.	70.		
Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Feet.*	*Trees.*
10	9.7	8.3	7.0	5.9	4.5	2.8	....	....	....	50	34
11	10.6	9.1	7.9	6.7	5.4	3.8	....	....	....	55	21
12	11.6	10.0	8.7	7.5	6.3	4.8	3.0	....	....	61	22
13	12.6	10.9	9.6	8.4	7.3	5.8	4.0	....	....	65	21
14	13.5	11.7	10.4	9.3	8.2	6.7	5.2	3.1	....	70	21
15	14.6	12.6	11.3	10.2	9.1	7.7	6.1	4.4	....	74	21
16	15.9	13.5	12.3	11.1	10.1	8.6	7.1	5.5	....	79	23
17	17.0	14.5	13.2	12.1	11.0	9.5	8.0	6.6	....	83	20
18	18.0	15.4	14.2	13.0	11.9	10.6	9.1	7.6	....	86	23
19	19.0	16.4	15.1	13.9	12.8	11.5	10.1	8.7	....	90	21
20	20.1	17.3	16.1	14.8	13.8	12.4	11.1	9.7	....	94	21
21	21.1	18.2	17.1	15.7	14.7	13.3	12.0	10.6	....	97	20
22	22.2	19.1	18.0	16.6	15.6	14.3	12.9	11.5	10.1	100	25
23	23.2	20.1	18.9	17.5	16.5	15.2	13.7	12.3	10.9	103	24
24	24.2	21.1	19.9	18.4	17.3	16.1	14.6	13.1	11.7	106	33
25	25.3	22.0	20.8	19.3	18.2	17.0	15.5	14.0	12.5	109	26
26	26.4	22.9	21.7	20.2	19.0	17.9	16.3	14.8	13.2	113	23
27	27.6	23.9	22.7	21.0	19.9	18.8	17.2	15.5	13.9	115	29
28	28.8	24.8	23.6	21.9	20.7	19.6	18.1	16.4	14.6	118	21
29	30.3	25.8	24.5	22.8	21.6	20.4	18.9	17.1	15.4	121	23
30	32.3	26.7	25.4	23.7	22.5	21.2	19.7	17.9	16.1	124	23
Total.	....	....	....	....	....	....	....	....	....	....	495

Approved:
JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *October 18, 1907.*

[Cir. 127]

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